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HYDROLOGIC RELATIONSHIP OF JEFFERSON COUNTY LANDFILL LEACHATE AND MERAMEC HEIGHTS AREA SPRINGS

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National Field Investigations Center-Denver

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HYDROLOGIC RELATIONSHIP OF JEFFERSON COUNTY LANDFILL LEACHATE & MERAMEC HEIGHTS AREA SPRINGS JEFFERSON COUNTY, MISSOURI

NATIONAL FIELD INVESTIGATIONS CENTER-DENVER

AND

REGION VII, KANSAS CITY, MISSOURI

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by

Jim V. Rouse

National Field Investigations Center-Denver
Denver, Colorado
and
Region VII, Kansas City, Kansas
April, 1973

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HYDROLOGIC RELATIONSHIP OF JEFFERSON COUNTY LANDFILL LEACHATE AND MERAMEC HEIGHTS AREA SPRINGS, JEFFERSON COUNTY, MISSOURI

BACKGROUND

During late 1967 or early 1968, a small, "head of hollow" landfill operation was initiated on the northwest side of Teligman Creek, an intermittent stream in the Meramec Heights area of Jefferson County, Missouri [Figure 1]. In this operation, solid waste of domestic and possible industrial origin was placed in tributary "hollows" of Teligman Creek, compacted, and covered with soil. Because of the great volume of solid waste generated by our society, the operation grew rapidly with increasing amounts of solid waste placed in the site.

During the latter part of 1968, reports were received by the U. S. Attorney and by the U. S. Federal Water Quality Administration, now Environmental Protection Agency (EPA), that a spring, known as "Kohl Spring" had turned black and the discharge had killed fish living in a small pond receiving the spring flow. Other springs, notably Averback Spring, also had showed signs of deterioration. The U. S. Attorney, on Nov. 23, 1971, requested the EPA to furnish information on the relationship of the landfill to the observed degradation, for possible legal action.

During April 1972 the Enforcement Director of EPA Region VII requested the National Field Investigations Center-Denver (NFIC-D) to

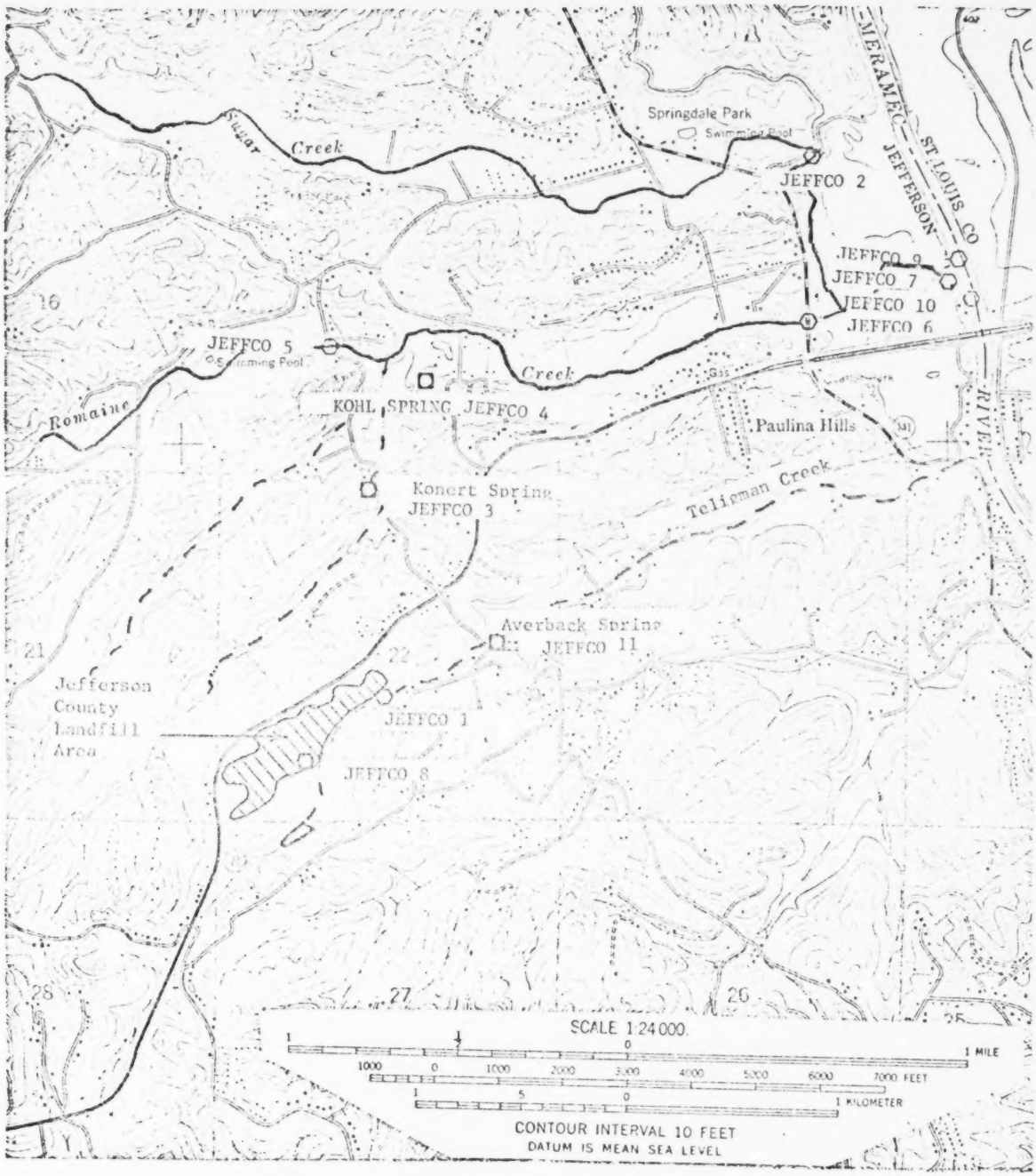

FIGURE 1. TOPOGRAPHIC MAP, JEFFERSON CO. LANDFILL AREA

□ SPRING SAMPLING SITE

○ STREAM SAMPLING SITE

review available data in the Region VII files, visit the site of the landfill, conduct necessary field studies, and report on the relationship of leachate from the landfill to observed contamination of springs in the area. This report provides information on the subsequent NFIC-D investigation.

One of the first studies of the relationship of Jefferson County leachate to the springs of the area is "*Technical Report on Ground-Water Contamination in the Meramac Heights Region of Jefferson County, Missouri*" November 1970, prepared by Environmental Response, a group of students at St. Louis and Washington Universities. This report provides valuable information on past history and problems in the area. The Kohl Spring discharge was reported to contain high coliform bacterial densities and higher-than-normal dissolved ions, especially iron. From the geology of the Meramac Heights region Environmental Response concluded that the major cause of the various problems with springs in the area was from landfill leachate. This group recommended that the Jefferson County landfill be closed immediately.

Two EPA geologists, Robert C. Scott of the San Francisco EPA Regional Office and Les McMillion, of the Robert S. Kerr Water Research Laboratory of EPA had previously visited the Meramac Heights region on September 17, 1970. Mr. McMillion concluded that the landfill was not a proper one. He pointed out that closing the landfill would not assure adequate protection and prevention of further ground-water pollution. Rather, it would be necessary to grade and maintain the site in such a way

as to prevent additional pollution from the infiltration of rainfall and movement of ground water through the emplaced refuse.

The EPA Region VII file contained a letter, dated February 14, 1972, from Wallace B. Howe, Director of the Missouri Geological Survey. Mr. Howe concludes that the landfill site is a poor location and that the Survey would not currently approve a landfill at the site. Mr. Howe recommends that the best solution is to complete the landfill operation as soon as possible, then cover the site to provide for rapid run-off, and construct lagoons or other treatment facilities to intercept and treat all leachate from the landfill. It was further recommended that all septic tanks in the area be eliminated as soon as possible.

The Regional Office files also contained a letter, dated May 31, 1972, from R. E. Schaefer, Supervisor of Environmental Sanitation, Region Three, Missouri Division of Health, addressed to the owners of the landfill. This letter requires that the company employ an experienced engineer to design treatment facilities for the leachate and to submit plans for the construction of these facilities no later than July 21, 1972. It is understood that this requirement was met.

Background information on the geologic and hydrologic environment in the Meramac Heights region is contained in the Environmental Response report and in a memorandum prepared by Mr. McMillion. Valuable information on the geologic conditions of the area is contained in Geologic Quadrangle Map Series No. 2, "*Geology of the Maxville Quadrangle, Jefferson*

and St. Louis Counties, Missouri, prepared by Bruce L. Stinchomb and L. D. Fellows of the Missouri Geological Survey, and the report *Engineering Geologic Map of Maxville Quadrangle, Jefferson County and St. Louis County, Missouri*, prepared in 1968 by Edwin E. Lutzen.

The landfill is located on limestones of the Burlington-Keokuk formation. It is situated less than one mile from the Maxville Monocline. Slightly younger formations, including the Warsaw and Salem formations, outcrop across the monocline. It is probable that the monocline serves as a barrier for ground-water movement. Kohl Spring is located very close to the north end of the faulted monocline.

Ground water in the area is derived from precipitation on nearby land surfaces, infiltrating through solution cavities in the various limestone formations, with minor recharge from septic tanks and sewage lagoons. Movement of water is largely subsurface, except during periods of extreme precipitation. Intermittant streams in the area generally are losing streams: i.e., the surface flow gradually seeps into the subsurface through solution cavities. They are large and afford little filtration for pollutants carried into these cavities. However, some neutralization of the acidic materials in the percolating water by the carbonate minerals comprising the limestone could occur. Such reactions can serve to change the composition of gases in the solution cavities and also affect the chemistry of dissolved pollutants in the ground water.

Additional information on the Kohl Spring area and its relationship to the Jefferson County landfill leachate is contained in *Kohl Spring-Biogeochemistry of a Blackwater System*, a thesis by James P. Murray, presented to the University of Missouri Graduate School, September 1972. This report concludes that the Kohl Spring contamination is largely a result of the Jefferson County landfill leachate. This is based on Mr. Murray's analyses of various chemical and bacteriologic variables, including fecal coliform densities, high trace metals (nickel, molybdenum, and copper), iron sulfide precipitation, unusual nitrogen-phosphorus ratio, and total dissolved solids concentrations. Mr. Murray's report is quite thorough and very strongly indicates a connection between the landfill leachate and the observed degradation of Kohl Spring.

RESULTS OF NFIC-D STUDY

The site of the Jefferson County landfill area was visited on June 2, 1972, by Jim V. Rouse, a geologist with the NFIC-D, accompanied by Karl F. Holtgraewe, Basin Engineer with the Missouri Clean Water Commission. The Jefferson County landfill is located to the southeast of Missouri Highway 21, along the western slope of Teligman Creek. Soil in the area is extremely rocky and in direct contact with solution cavaties in the underlying limestone. Outcrops of the limestone along Teligman Creek contain numerous solution cavaties. Dip of the formation is from Teligman Creek directly to Kohl Spring, in the direction of the faulted Maxville monocline. During the June visit to the site, aburdant

ferric hydroxide, "yellowboy", and other metal precipitates were noted along Teligman Creek between the active landfill and the downstream property of Jefferson County landfill. Leachate was flowing from the toe of the landfill and disappearing into the solution cavities at a point near the downstream boundary of the Jefferson County landfill. During the June visit Kohl Spring was clear, with the discharge channel coated with "yellowboy" or ferric hydroxide, overlying a deposit of black sulfide material.

Romaine Creek at the Highway 141 bridge was noted to have manganese staining on the rocks of the stream bed. This staining was not present in Romaine Creek upstream of the Kohl Spring discharge.

Aerial photographs of the Jefferson County landfill area, taken February 23, 1968, prior to the bulk of the landfill activity, were obtained and studied for geohydrologic data. The start of flow in Teligman Creek was noted to originate at a point now covered by the landfill, corresponding to the site of the major present leachate production. Flow in Teligman Creek disappeared at approximately the point where the leachate was observed to be infiltrating to the solution cavities.

Subsequent to the NFIC-D June 1972 visit to the site, the landfill operators constructed a series of earthen ponds in the Teligman Creek flood plain. The expressed purpose of these ponds was to retain and evaporate all the leachate. However, it should be noted that, at the landfill site, precipitation equals or exceeds evaporation, with the

result that a water volume equal to, or greater than, the leachate inflow must be discharged from the ponds through seepage and/or overflow. The ponds act to oxidize a portion of the waste and move the point of ground-water recharge from the open solution cavities to an area of soil cover; this should result in ion exchange and some filtration.

Personnel of the NFIC-D and Region VII offices of EPA conducted bacteriological and heavy-metals sampling in the Meramec Heights area during the period August 30 to September 5, 1972. Results of this investigation were reported in a memorandum, dated November 20, 1972, to the Director, Division of Enforcement, Region VII, from Jim V. Rouse, NFIC-D. Sampling stations used in this and subsequent sampling activities are shown on Figure 1 and listed in Table 1. Analytical results achieved for bacteriological and heavy-metals content are given respectively in Tables 2 and 3.

The sampling activities of August 30 to September 5, 1972 were conducted under search warrant procedures, following the issuance of a search-warrant by the U. S. District Court, St. Louis. Several items of data were strongly indicative of a connection between the Jefferson County landfill leachate and the Kohl Spring discharge. These include high conductivity values for both the landfill leachate and Kohl Spring; acid or near-neutral pH values for both the leachate and Kohl Spring, in comparison to alkaline conditions for all other waters in the area; negative redox potentials for both Kohl Spring

TABLE 1

SAMPLING SITES UTILIZED IN
MERAMEC HEIGHTS, MISSOURI SAMPLING

Station Number	Location
JEFFCO 1	Teligman Creek, downstream from Jeffco Landfill
JEFFCO 2	Sugar Creek, upstream of Romaine Creek
JEFFCO 3	Konert Spring
JEFFCO 4	Kohl Spring
JEFFCO 5	Romaine Creek, upstream of Konert Spring
JEFFCO 6	Romaine Creek at Highway 141 Bridge
JEFFCO 7	Sugar Creek at mouth
JEFFCO 8 (A,B,C,D,E)	Jeffco Landfill leachate samples
JEFFCO 9	Meramec River, upstream of Saline Creek
JEFFCO 10	Meramec River, downstream from Saline Creek
JEFFCO 11	Averback Spring

TABLE 2

SUMMARY OF MICROBIOLOGICAL DATA
JEFFERSON COUNTY, MISSOURI LANDFILL AREA
ANALYSIS BY REGION VII, EPA

Station	1972 Date	Time	Over 8 Hours?	Total Colif.	Fecal Colif.	Fecal Strept.
				Per 100 ml		
JEFFCO-2	8/31	0820	Yes	4,400	410	310
JEFFCO-2	9/5	1120	Yes	9,000	980	610
JEFFCO-3	8/31	0925	No	220	< 10	< 10
JEFFCO-3	9/5	1230	Yes	1,500	60	420
JEFFCO-4	8/31	0909	No	1,500	20	70
JEFFCO-4	9/5	1213	Yes	1,100	130	250
JEFFCO-5	8/31	0937	No	13,000	6,500	580
JEFFCO-5	9/5	1250	No	3,100	700	400
JEFFCO-6	8/31	0750	Yes	4,500	660	890
JEFFCO-6	9/5	1055	Yes	3,600	330	620
JEFFCO-7	8/31	0722	Yes	4,100	220	560
JEFFCO-7	9/5	1039	Yes	18,000	1,400	510
JEFFCO-8	9/5	1535	No	430,000	2,000	30,000
JEFFCO-8-A	9/5	1550	No	< 1,000	< 1,000	< 1,000
JEFFCO-8-B	9/5	1610	No	200,000	5,200	6,100
JEFFCO-9	9/5	1155	Yes	300	30	< 10

TABLE 3

RESULTS OF LABORATORY ANALYSES, HEAVY METALS SAMPLES, JEFFERSON COUNTY LANDFILL SURVEY

Station	Date Sampled	Cd mg/l	Cu mg/l	Fe mg/l	Pb mg/l	Li µg/l	Mn mg/l	Ni mg/l	Sn mg/l	Zn mg/l	Hg µg/l
Jeff. Co. 2	8/30/72	0.006	< 0.04*	0.81	0.08	67.7	0.21	< 0.02*	1.9	0.03	0.7
	8/31/72	< 0.004*	< 0.04*	0.95	< 0.05*	56.9	0.26	0.02	2.5	0.02	0.4
	9/1/72	0.008	< 0.04*	0.80	< 0.05*	54.9	0.24	0.03	3.6	0.03	< 0.2*
	9/5/72	0.009	< 0.04*	0.75	< 0.05*	40.2	0.22	0.03	0.8	0.02	0.5
	Mean	< 0.00675	< 0.04	0.83		54.9	0.23	< 0.025	2.2	0.02	---
Jeff. Co. 3	8/30/72	0.005	< 0.04*	0.09	< 0.05*	13.1	< 0.02*	< 0.02*	0.8	< 0.01*	0.7
	8/31/72	0.004	< 0.04*	0.46	< 0.05*	7.2	< 0.02*	< 0.02*	1.8	0.03	< 0.2*
	9/1/72	0.009	< 0.04*	0.22	< 0.05*	6.3	< 0.02*	0.04	3.0	0.05	< 0.2*
	9/5/72	0.010	< 0.04*	0.16	< 0.05*	5.9	< 0.02*	0.02	0.9	0.05	< 0.2*
	Mean	0.007	< 0.04	0.23	< 0.05	8.1	< 0.02	< 0.025	1.6	< 0.0375	---
Jeff. Co. 4	8/30/72	0.005	< 0.04*	6.7	< 0.05*	20.7	5.2	0.02	2.7	0.04	0.8
	8/31/72	0.007	< 0.04*	6.6	< 0.05*	13.8	5.1	0.07	1.6	0.02	< 0.2*
	9/1/72	0.012	< 0.04*	7.6	< 0.05*	13.3	5.2	0.04	2.6	0.07	< 0.2*
	9/5/72	0.008	< 0.04*	5.8	< 0.05*	11.3	4.6	0.06	0.5	0.04	< 0.2*
	Mean	0.008	< 0.04	6.7	< 0.05	14.8	5.0	0.05	1.8	0.04	---
Jeff. Co. 5	8/30/72	< 0.004*	< 0.04*	0.54	< 0.05*	7.4	0.07	< 0.02*	1.8	0.03	0.2
	8/31/72	0.005	< 0.04*	0.85	< 0.05*	5.5	0.04	0.05	1.6	0.06	< 0.2*
	9/1/72	0.006	< 0.04*	0.59	< 0.05*	13	< 0.02*	0.03	1.9	0.03	< 0.2*
	9/5/72	0.006	< 0.04*	0.73	< 0.05*	5.9	0.03	< 0.02*	1.8	0.03	< 0.2*
	Mean	< 0.005	< 0.04	0.59	< 0.05	8.0	< 0.0425	< 0.03	1.8	0.05	---
Jeff. Co. 6	8/30/72	0.004	< 0.04*	0.29	< 0.05*	8.7	0.06	< 0.02*	1.4	0.03	0.8
	8/31/72	0.011	< 0.04*	0.94	0.07	6.9	0.10	0.04	1.2	0.05	0.4
	9/1/72	0.009	< 0.04*	0.39	< 0.05*	6.2	0.03	0.02	1.8	0.03	0.6
	9/5/72	0.009	< 0.04*	0.45	< 0.05*	6.3	0.03	0.01	1.1	0.05	< 0.2*
	Mean	0.008	< 0.04	0.52	< 0.05	7.0	0.06	< 0.02	1.4	0.04	---
Jeff. Co. 7	8/30/72	0.005	< 0.04*	0.66	< 0.05*	46.6	0.26	0.02	1.5	0.07	0.8
	8/31/72	0.008	< 0.04*	0.84	< 0.05*	44.9	0.33	0.05	1.5	0.06	0.2
	9/1/72	0.008	0.04	0.68	< 0.05*	48.9	0.29	0.05	1.0	0.06	< 0.2*
	9/5/72	0.007	< 0.04*	1.2	< 0.05*	42.9	0.32	0.04	0.8	0.05	0.4
	Mean	0.007	< 0.04	0.84	< 0.05	45.8	0.30	0.04	1.2	0.06	---
Jeff. Co. 8 Leachete	9/5/72	0.023	0.08	26	0.42	110	1.4	0.19	5.5	8.8	< 0.2*
Jeff. Co. 8A Samples	9/5/72	0.025	0.06	580	< 0.05*	90.9	100	0.52	4.0	1.3	< 0.2*
Jeff. Co. 8B	9/5/72	0.004	0.06	26	0.11	25.1	2.0	0.12	3.5	0.35	< 0.2*
Jeff. Co. 8C**	9/5/72	< 0.004*	0.04	11	< 0.05*	11.7	0.15	0.02	1.5	0.08	< 0.2*
Jeff. Co. 9	9/5/72	< 0.004*	0.04	0.83	< 0.05*	7.5	0.07	< 0.02*	0.7	0.07	< 0.2*
DETECTION LIMIT		0.004	0.04	0.01	0.05	0.14	0.02	0.02	0.4	0.01	0.2

*Minimum Detectable Limits.
**Sample not acidified in the field.

and the landfill leachate, in comparison to positive potential in all other waters in the area; high bacterial densities in Kohl Spring and the landfill leachate; and high levels of cadmium, iron, and manganese in Kohl Spring and the landfill leachate, in comparison to other natural waters of the area.

While the bacteriological and heavy-metals sampling, during the period of August 30 through September 5, was strongly indicative of a connection between the leachate and Kohl Spring, additional data were desirable to support the initiation of litigation. Accordingly, a dye and chemical tracer study was conducted to determine the relationship between Kohl Spring and the landfill leachate. Additional data were collected to relate the Kohl Spring discharge to the Meramac River, a navigable stream. During the first phase of the tracing study, Rhodamine WT dye was placed in the discharge of Kohl Spring and visually observed. The dye was placed on October 24, 1972, at approximately 12:30 PM. By October 25, at 2 PM, the dye was observed flowing from the mouth of Sugar Creek into the Meramac River, and also, it spread over a distance of approximately 50 yards along the west bank of the river. Thus, it was obvious that any dissolved constituents in the Kohl Spring discharge would move by way of Romaine and Sugar Creeks into the Meramac River, a navigable stream.

During the second phase of the study, 100 pounds of lithium bromide brine containing 54 pounds of solid lithium bromide, was injected in the

seepage from the toe of the Jefferson County landfill at 12:55 PM, October 25, 1972. This chemical tracer placement was witnessed by Gene Laningham, of Browning-Ferris Industries, owner of the landfill site. Grab and composite samples were collected from various sites throughout the Meramec Heights region. Sample collection continued for a two-week period. Unfortunately, the area was subjected to an extremely large precipitation event commencing October 31, 1972, with the result that flows from Kohl Spring and other springs in the area, as well as surface stream flows, were greatly increased.

Field conductivity measurements were made at the time of sample collection. Hourly conductivity data were collected from a composite sampler emplaced in Kohl Spring [Table 4]. Other sites were sampled daily. The samples were collected under custody procedure and transmitted to the University of Missouri, Columbia, for analysis. Lithium analysis were accomplished by atomic absorption techniques, while bromine analysis was performed by neutron activation methods.

The lithium and bromine data for Kohl Spring composited samples, as given in Table 5, show a great increase in concentration during the afternoon of October 29, approximately four days after the lithium bromide brine was placed in the Jefferson County landfill leachate. The increase in bromine concentration was especially pronounced, from less than 2,000 to more than 4,000 µg/l in a single six-hour composite period. The grab samples from Kohl Spring also displayed a concentration increase, although less pronounced. This was immediately prior to the beginning

TABLE 4
HOURLY CONDUCTIVITY DATA, MICROMHOS/CM,
KOHL SPRING DISCHARGE,
MERAMEC HEIGHTS, MISSOURI
1972

Time	Oct 25	Oct 26	Oct 27	Oct 28	Oct 29	Oct 30	Oct 31	Nov 1	Nov 2	Nov 3	Nov 4	Nov 5	Nov 6	Nov 7	Nov 8
0100	-	1450	1500	1650	1700	1700	1500	1500	850	775	900	975	900	975	900
0200	-	1150	1500	1350	1700	1700	1600	1500	850	775	900	925	900	975	900
0300	-	1150	1400	1700	1700	1700	1400	1450	825	800	900	925	900	975	900
0400	-	1300	1500	1700	1700	1700	1700	1400	800	800	900	925	900	975	900
0500	-	1100	1500	1700	1700	1700	1700	1400	750	800	925	925	900	975	900
0600	-	1150	1500	1700	1700	1700	1700	1400	750	800	950	950	900	975	900
0700	-	1175	1500	1700	1700	1700	1700	1500	750	800	950	975	900	975	925
0800	-	1200	1500	1400	1700	1700	1700	1500	750	850	950	975	950	975	925
0900	-	1075	1550	1700	1700	1700	1700	1500	725	850	950	1000	950	975	925
1000	-	1225	1600	1550	1700	1700	1700	1100	725	875	1000	1025	1000	975	950
1100	-	1450	1700	1700	1700	1700	1700	1700	1000	700	850	900	950	975	900
1200	1150	1500	1650	1700	1700	1700	1700	1000	700	850	900	900	975	900	-
1300	1400	1500	1650	1700	1700	1700	1700	1000	700	850	900	900	975	900	-
1400	1300	1350	1650	1700	1700	1700	1600	1000	700	850	900	900	975	900	-
1500	1075	1500	1650	1700	1700	1700	1500	1200	700	850	900	900	975	900	-
1600	1100	1500	1650	1700	1700	1700	1500	1400	700	875	900	900	975	900	-
1700	1000	1500	1650	1700	1700	1700	1500	1400	700	875	900	900	975	900	-
1800	1000	1500	1650	1700	1700	1700	1400	1400	725	875	900	900	975	900	-
1900	1400	1350	1650	1700	1700	1700	1400	1150	750	900	925	925	975	900	-
2000	1400	1400	1650	1700	1700	1700	1350	1000	750	900	925	925	975	900	-
2100	1275	1500	1650	1700	1700	1700	1400	975	750	900	925	900	975	900	-
2200	1400	1400	1650	1700	1700	1700	1400	1000	750	900	925	900	975	900	-
2300	1400	1500	1650	1700	1700	1700	1500	1000	750	900	925	900	975	900	-
2400	1400	1500	1650	1700	1700	1700	1500	950	750	900	950	925	975	900	-

TABLE 5
COMPOSITE SAMPLES FROM KOHL SPRING,
JEFFERSON COUNTY, MISSOURI

1972 Date	Composite Period From	Composite Period Through	Lithium, µg/l	Bromide, µg/l
10/25	1200	1700	2.9	1140
	1800	2300	2.4	1370
10/26	0001	0500	2.4	1490
	0600	1100	2.3	1550
	1200	1700	2.3	1740
	1800	2300	2.5	1700
10/27	0001	0500	2.3	1570
	0600	1100	2.4	1590
	1200	1700	2.6	1540
	1800	2300	2.4	1730
10/28	0001	0500	2.3	1670
	0600	1100	2.2	1690
	1200	1700	2.2	1720
	1800	2300	2.8	1770
10/29	0001	0500	2.3	1750
	0600	1100	4.6	1780
	1200	1700	13	1970
	1800	2300	22	4240
10/30	0001	0500	32	2170
	0600	1100	35	1740
	1200	1700	47	1790
	1800	2300	52	2840
10/31	0001	0500	57	3410
	0600	1100	66	3450
	1200	1700	58	3150
	1800	2300	57	2630
11/1	0001	0500	73	2980
	0600	1100	68	2990
	1200	1700	59	2420
	1800	2300	54	2070
11/2	0001	0500	26	1260
	0600	1100	20	1300
	1200	1700	15	834
	1800	2300	14	950
11/3	0001	0500	14	1150
	0600	1100	14	946
	1200	1700	12	1290
	1800	2300	12	1110
11/4	0001	0500	12	1330
	0600	1100	12	1050
	1200	1700	12	1150
	1800	2300	10.7	1110

TABLE 5
COMPOSITE SAMPLES FROM KOHL SPRING,
JEFFERSON COUNTY, MISSOURI
(CONTINUED)

1972 Date	Composite Period From	Composite Period Through	Lithium, µg/l	Bromide, µg/l
11/5	0001	0500	10.7	1140
	0600	1100	10.3	1090
	1200	1700	9.6	1220
	1800	2300	8.7	1010
11/6	0001	0500	8.2	1060
	0600	1100	7.4	1140
	1200	1700	7.1	993
	1800	2300	6.8	1080
11/7	0001	0500	6.8	1080
	0600	1100	6.6	1070
	1200	1700	6.2	763
	1800	2300	6.5	972
11/8	0001	0500	6.5	1080
	0600	1100	7.9	1040

of the precipitation event. Samplers records indicate the peak rain was during the night of October 31-November 1. An examination of the Kohl Spring discharge data indicate an increase in flow starting 10 PM, October 30, with the peak flow not occurring until November 1. Grab samples collected from Konert and Averback Springs [Table 6] disclose a slight increase in the concentration of lithium and bromide. The increase could be attributed to either the injection or the precipitation event.

The passage of the lithium bromide tracer downstream would have occurred during the period of surface runoff. Because the first overland runoff dissolves salts from the land surface, it is impossible to state, on the basis of the chemical data, that the tracer entered the Meramec River. However, the previous dye study amply demonstrated that there was hydraulic continuity between Kohl Spring and the Meramec River.

CONCLUSIONS

(1) The chemical and dye studies prove a definite hydraulic connection between the Jefferson County landfill leachate ponds and Kohl Spring and between Kohl Spring and the Meramec River. A possible connection is also indicated between the leachate and Averback and Konert Springs.

(2) The construction of ponds to detain the leachate, together with movement of the landfill operations to upstream points along Teligman Creek, has probably reduced the pollution of Kohl Spring.

TABLE 6
RESULTS OF LITHIUM, BROMIDE ANALYSIS ON
GRAB SAMPLES COLLECTED IN
MERAMEC HEIGHTS AREA, MISSOURI

Station	1972 Date	Time	Lithium µg/l	Bromide µg/l
JEFFCO 2 SUGAR CREEK UPSTREAM OF ROMAINE CREEK				
	10/26	0945	32	615
	10/27	0925	33	719
	10/28	0925	35	653
	10/29	0925	34	621
	10/30	0925	34	728
	10/31	0925	35	779
	11/1	1020	106	50.2
	11/2	0925	4.2	83.1
	11/3	0925	4.8	152
	11/4	0925	4.9	49.2
	11/5	0925	4	25.8
	11/6	0925	9.5	238
	11/7	0925	13	332
	11/8	0925	14	319
JEFFCO 3 KONERT SPRING				
	10/26	1000	0.8	57.6
	10/27	0940	0.7	59.9
	10/28	0940	0.8	57.4
	10/29	0940	0.7	54.2
	10/30	0940	0.93	62.4
	10/31	0940	1.4	64.7
	11/1	1030	1.3	65.8
	11/2	0950	1.12	41.6
	11/3	0940	0.99	48.5
	11/4	0940	0.62	45.1
	11/5	0940	0.63	46.9
	11/6	0940	0.72	50.5
	11/7	0940	0.69	67.6
	11/8	0940	0.69	47.7
JEFFCO 4 KOHL SPRING				
	10/25	1310	25*	1584
	10/26	1025	2.2	1570
	10/27	1015	2.2	1530
	10/28	1015	2.4	1580
	10/29	1025	7.8	1610
	10/30	1025	43	2290
	10/31	1025	69	2780
	11/1	1255	50	2230
	11/2	1025	15	595
	11/3	1025	13	746

TABLE 6
RESULTS OF LITHIUM, BROMIDE ANALYSIS ON
GRAB SAMPLES COLLECTED IN
MERAMEC HEIGHTS AREA, MISSOURI
(CONTINUED)

Station	1972 Date	Time	Lithium µg/l	Bromide µg/l
	11/4	1025	12	945
	11/5	1025	9.2	1070
	11/6	1025	7.2	942
	11/7	1025	6.5	954
	11/8	1025	6.1	816
JEFFCO 5 ROMAINE CREEK UPSTREAM OF KONERT SPRING				
	10/26	1005	0.74	71.2
	10/27	0950	0.68	72.0
	10/28	0950	0.81	67.3
	10/29	0950	0.82	69.1
	10/30	0950	0.64	73.6
	10/31	0950	1.32	149
	11/1	1040	25	16.1
	11/2	0950	1.3	52.2
	11/3	0950	1.16	52.2
	11/4	0950	1.14	51.7
	11/5	0950	0.89	48.5
	11/6	0950	0.65	47.4
	11/7	0950	0.8	52.0
	11/8	0950	0.73	49.4
JEFFCO 6 ROMAINE CREEK AT HIGHWAY 141 BRIDGE				
	10/26	0935	1.3	355
	10/27	0915	0.9	358
	10/28	0915	0.93	228
	10/29	0915	0.72	361
	10/30	0915	0.83	317
	10/31	0915	3.3	348
	11/1	1010	52	42.3
	11/2	0915	2.5	167
	11/3	0915	1.9	157
	11/4	0915	1.9	175
	11/5	0915	3.5	45.2
	11/6	0915	1.4	186
	11/7	0915	1.3	176
	11/8	0915	1.2	172

TABLE 6
RESULTS OF LITHIUM, BROMIDE ANALYSIS ON
GRAB SAMPLES COLLECTED IN
MERAMEC HEIGHTS AREA, MISSOURI
(CONTINUED)

Station	1972 Date	Time	Lithium µg/l	Bromide µg/l
JEFFCO 7 SUGAR CREEK AT MOUTH				
	10/26	0925	23	612
	10/27	0900	25	600
	10/28	0900	25	481
	10/29	0900	25	546
	10/30	0900	25	650
	10/31	0900	25	441
	11/1	0900	33	155
	11/2	0900	4	80.1
	11/3	0900	3.6	134
	11/4	0900	5.4	19.5
	11/5	0900	3.7	23.2
	11/6	0900	3.6	77.2
	11/7	0900	3	69.5
	11/8	0900	3.8	106
JEFFCO 11 AVERBACK SPRING				
	10/26	1140	0.99	2660
	10/27	1005	0.94	2250
	10/28	1005	0.93	2230
	10/29	1005	0.85	2440
	10/30	1005	0.81	1880
	10/31	1005	2.5	1740
	11/1	1345	0.95	635
	11/2	1005	0.74	131
	11/3	1005	0.68	195
	11/4	1005	0.7	233
	11/5	1005	0.74	296
	11/6	1005	0.78	312
	11/7	1005	0.82	313
	11/8	1005	0.81	324

* Probably contaminated by equipment associated with brine addition.

However, the ponds do seep, recharging the ground water. In an area, such as the landfill site, where precipitation equals or exceeds evaporation, it is obvious that ponds cannot be used to retain leachate without either overflowing or seeping.

(3) The volume of leachate produced can be reduced by preventing, through proper surface grading and sealing, infiltration of precipitation and by draining ground water that now is moving through the landfill. This drainage can be accomplished by wells or properly placed toe drains. Reduction in the leachate volume will reduce the ground-water recharge.

RECOMMENDATIONS

It is recommended that:

(1) The landfill operational permit not be renewed by the Missouri Division of Health, and the landfill be closed June 30, 1973.

(2) Following landfill closure the following actions be taken:

(a) The site be graded and sealed to minimize infiltration;

(b) Wells or drains be installed, to prevent movement of ground water through the refuse;

(c) The leachate ponds be maintained as detention basins, to reduce ground-water recharge and maintenance of ponds, wells, and drains shall be required of the property owner.

(3) Great care be exercised in the selection of future landfill sites, with "head-of-hollow" landfills on areas of thin, rocky soils overlying cavernous limestone bedrock being avoided and no landfill activities being permitted on the southeast side of Teligman Creek in the vicinity of the present landfill site.

BIBLIOGRAPHY

Environmental Response, November 1970, *Technical Report on Ground-Water Contamination in the Meramec Heights Region of Jefferson County, Missouri*, Chemistry Department, St. Louis University. St. Louis, Missouri.

Lutzen, Edwin E., May 1968, *Engineering Geology of the Maxville Quadrangle, Jefferson and St. Louis Counties, Missouri*, Engineering Geology Series No. 1, Missouri Division of Geological Survey and Water Resources. Rolla, Missouri.

McMillion, Leslie G., October 16, 1970, Personal Communication.

Murray, James P., September, 1972, *Kohl Spring-Biogeochemistry of a Blackwater System*, M. S. Thesis, University of Missouri. Columbia, Missouri.

Rouse, Jim V., November 20, 1972, Personal Communication.

Stinchcomb, Bruce L., and L. D. Fellows, May, 1968, *Geology of the Maxville Quadrangle, Jefferson and St. Louis Counties, Missouri*, Geologic Quadrangle Map Series No. 2, Missouri Division of Geological Survey and Water Resources. Rolla, Missouri.